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NOTES ON SOME CARBONIFEROUS COCHLIODONTS WITH DESCRIPTIONS OF SEVEN NEW SPECIES

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The following article is the result of the writer's study of the teeth of the genera *Cochliodus*, *Psephodus*, *Sandalodus*, and *Deltodus*, in the collection of Walker Museum at the University of Chicago. In the collection are several hundred specimens of the teeth of *Sandalodus* and *Deltodus*, and more than fifty of *Cochliodus* and *Psephodus*.

The writer is under obligation to Dr. Stuart Weller for the privilege of studying the collection at Walker Museum, and to Professor C. E. McClung for the loan of specimens from the Kansas University Museum. Acknowledgment is due Professor S. W. Williston and Dr. Stuart Weller for helpful suggestions during the investigation.

Psephodus Agassiz

Cochliodus Agassiz, 1838 (*Recherches Poissons fossiles*, Vol. III, p. 174).

Cochliodus Portlock, 1843 (*Geological Report on Londonderry*, Plate XIV, Fig. 4).

Cochliodus McCoy, 1855 (*British Paleozoic Fossils*, p. 622).

Psephodus Agassiz, 1859 (MSS in the Enniskillen Collection).

Psephodus Morris and Roberts, 1862 (*Quarterly Journal of the Geological Society*, Vol. XVIII, p. 101).

Aspidodus Newberry and Worthen, 1866 (*Paleontology of Illinois*, Vol. II, p. 92).

Taeniodus St. John and Worthen, 1883 (*ibid.*, Vol. VII, p. 75).

A jaw of *Psephodus* with four teeth in place is preserved in Walker Museum at the University of Chicago. The full dentition of the jaw is probably not present, the front teeth having their anterior margins thick and truncated, as for articulation with other teeth. The missing anterior teeth were probably triangular in form and considerably smaller than those with which they articulate, but no place remains on the jaw for the helodoid teeth which have been so generally considered as forming a component part of the dentition of this genus.

The history of the belief in the association of helodoid teeth with the large plates on the jaw of *Psephodus* is interesting and is briefly sketched below.

The earliest mention of this supposed association is in a letter written by Captain Jones to Portlock, and published in 1843,¹ in which he says : "I think I am enabled to show that, however distinct and well marked the extremes may be, yet *Helodus planus* passes into *Cochliodus magnus*." In connection with this statement no evidence is given for its support. In publishing the results of his investigations on the arrangement of *Psephodus* teeth, Davis says in summary:

That a row of three principal teeth increasing in size backward were attached to each cartilaginous ramus of the jaw; that the diameter of the jaw, as indicated by the groove or channel on the under surface of the teeth, diminished toward the symphysis; that a long narrow tooth was placed in front of the anterior one; and that a series of at least three helodoid teeth were placed behind it extending over the palate and increasing in size backward.²

The same year St. John and Worthen published the results of their studies on this genus and described an entirely different arrangement of the teeth. They conclude that—

While the median portion of the rami of the jaw of *Psephodus* was enveloped by a moderately contorted dental plate, constituting its chief point of resemblance to *Cochliodus*, this plate was flanked on either side by a series of teeth disposed in rows from within outward similar to the occurrence of the teeth in the jaws of *Cestracion*. Therefore the solid triturating plates of *Psephodus* are not strictly homologous with the large posterior teeth of *Cochliodus*, but they are more properly designated as median teeth of the rami of the jaws³

In 1885 Traquair published his conclusions as to the arrangement of *Psephodus* teeth, saying:

On the whole, I consider that view most likely to be correct which would ascribe to the mouth of *Psephodus* four large tooth plates, two above and two below, each occupying on the ramus a position similar to that of the row of the largest teeth of *Cestracion*, or of the so-called median teeth of *Cochliodus*, but that of the upper jaw differing slightly in form from the one opposed to it below. . . . Teeth of different forms seem to have been present in the jaw, external to and in front of the large plate; those in its immediate vicinity belonging more or less to the category of *Helodus planus*. . . . But the front of the jaw was armed

¹ Portlock, *Geological Report on Londonderry* (1843), p. 462.

² *Scientific Transactions of the Royal Dublin Society*, Vol. I (1883), p. 417, Plate LV, Figs. 1-4.

³ St. John and Worthen, *Paleontology of Illinois*, Vol. VII (1883), p. 64.

with small teeth belonging to the type which has been designated as *Lophodus* by Romanowski, and the forms *didymus* and *laevissimus*, both named as species of *Helodus* by Agassiz.¹

During the progress of the present investigation a study of a portion of the types of *Psephodus crenulatus* and *P. obliquus*, in addition to the specimen already mentioned with the teeth in position, and described in this paper as *Psephodus legrandensis*, has led to the following conclusions: The teeth called median mandibular by St. John and Worthen² are posterior and correspond to the posterior teeth of *Cochliodus*. The teeth called median maxillary by the same authors are median, but not in the sense that they used the term. They articulate behind with the large posterior plates and in front with the small anterior teeth, and do not articulate with helodoid teeth, as St. John and Worthen thought. In this genus there is nothing that enables us to distinguish the maxillary from the mandibular teeth. Teeth like those called mandibular by St. John and Worthen have been found in place on the same jaw with those called maxillary. (See Plate I, Fig. 2.) All of the teeth of *Psephodus* that have been described belong in the categories hitherto known as median mandibular and median maxillary teeth, and, as before said, they occur on the same jaw.

In previous publications the commonly expressed opinion has been that helodoid teeth were present on the same jaw with the large grinding plates of *Psephodus*, although very little evidence in support of this has been forthcoming. The only evidence that seems to be of much weight in its support is that furnished by a specimen described by Traquair in 1885.³ In this specimen forty-four helodoid teeth are preserved on the same slab with two of the large *Psephodus* teeth. It is no uncommon occurrence for teeth of different species to be preserved in close association, and the mere fact of such an association proves nothing, although, so long as no evidence to the contrary was forthcoming, it might well suggest the possibility that all the associated teeth belonged originally in the same jaw. Traquair's interpretation of the original position of these teeth in

¹ Traquair, *Geological Magazine*, 1885, p. 343.

² *Paleontology of Illinois*, Vol. VII, Plate I, Figs. 1 and 2, pp. 66 and 67.

³ *Geological Magazine*, 1885, pp. 337-44.

the jaw from their present positions on the slab shows that they are badly disarranged and might easily come from two or more specimens. He says¹ that of the two large teeth one belongs to the form called by Davis posterior, and the other to the form called median, but that they are not associated in such a way as to lend any support to that author's theory as to their arrangement. But the specimen of *P. legrandensis* furnishes positive evidence that Davis' theory in regard to the linear arrangement of the teeth is correct, with certain modifications. Only two large teeth are present in Traquair's specimen, while at least eight are necessary for the full dentition of both jaws. The teeth are so associated that Traquair concludes that the large plates occupied a position on the ramus similar to that of the median teeth of *Cochliodus*, and that helodoid teeth were arranged in front and external to them; but the specimen of *Psephodus legrandensis* before mentioned shows that such was not the position of the large plates, and that helodoid teeth could not have occupied the supposed place with reference to them.

Although the linear arrangement of the teeth of *Psephodus* postulated by Davis is in part correct, the inner margins of the teeth are placed outward in his restoration, as has been pointed out by Traquair,² and a glance at the dentition of *P. legrandensis* (Plate I, Fig. 2) shows that there was no place on the jaw for helodoid teeth. On each ramus of the jaw one large posterior tooth, one median tooth, usually much smaller, but in some species nearly as large as the posterior tooth, and probably one small triangular anterior tooth, are present. But instead of the teeth being arranged in a semi-circle, as Davis supposed, those of the two rami touch or approach each other very closely along the median line of the long axis of the jaw.

A comparison of the dentition of *Psephodus*, as shown in *P. legrandensis*, with that of *Cochliodus* brings out certain striking similarities. The arrangement of the large *Cochliodus* teeth is similar to that of *Psephodus*, the principal difference being that they do not meet along the median line, as in *Psephodus*, but spread apart, leaving a V-shaped area. The specimen from which Newberry and Worthen drew their conclusion that helodoid teeth were associated

¹ *Ibid.*, p. 342.

² *Ibid.*, p. 342.

on the same jaw with *Cochliodus* teeth furnishes little evidence to support that hypothesis. The teeth are not in position, and they have the appearance of having been accidentally associated. Owen has shown¹ almost beyond question that *Cochliodus* had only three teeth on each ramus of the jaw, and more evidence than a few *Helodus* teeth found preserved in close association with *Cochliodus* teeth is necessary to demonstrate that they belonged in the same mouth. Thus it seems probable that in *Cochliodus* as well as in *Psephodus* no helodoid teeth were present in the dentition.

***Psephodus legrandensis* sp. nov.**

(Plate I, Fig. 2)

A small species. Median tooth 5^{mm} broad, 8^{mm} along inner margin, 5^{mm} along outer margin. Inner posterior angle acute and produced backward; outer posterior angle obtuse, rectangular on both sides in front. Tooth strongly enrolled transversely, not arched longitudinally. Inner margins of the two median teeth parallel to each other when in position on the jaw, and approaching very closely on the median line. Posterior teeth subpentagonal in outline, 11^{mm} from posterior inner angle to anterior angle of outer edge, 6^{mm} along articular edge in median line, 8^{mm} along articular edge for anterior tooth. Teeth strongly arched longitudinally, little arched transversely, not ridged or furrowed. Enamel everywhere finely punctate. Edges not crenulate.

The posterior teeth of this species are readily distinguished from *P. crenulatus*, *P. obliquus*, and *P. placenta* by their smaller size, comparative narrowness, and greater longitudinal arching. The median teeth are more strongly enrolled transversely and proportionately narrower than those of the species above mentioned. The median teeth are distinguished from those of *P. acutus* by their smaller size, greater enrollment and the posterior angle being much less produced.

Formation and locality: Kinderhook limestone; Legrand, Iowa.

Paleontological Collection, Walker Museum, No. 10038.

***Psephodus acutus* sp. nov.**

(Plate I, Fig. 1)

Type and only specimen observed a median tooth. Measurements: 10^{mm} along the inner margin, 5^{mm} along the outer margin, 7^{mm} along the posterior articular edge, 6^{mm} along the anterior articular edge. Tooth not arched longitudinally, considerably enrolled transversely. Outer and inner margins parallel.

¹*Geological Magazine*, 1867, pp. 59-63.

P. acutus differs from *P. legrandensis* in the posterior inner angle being much more produced, in being less enrolled transversely, in its greater breadth, and in the anterior and inner margins meeting in a slightly more acute angle. The species is a little larger than *P. legrandensis*. The surface of the enamel is everywhere finely punctate.

Formation and locality: Coal Measures; LaSalle, Illinois.

Paleontological Collection, Walker Museum, No. 10036.

***Psephodus carbonarius* sp. nov.**

(Plate I, Fig. 7)

Type and only specimen observed, a posterior tooth. Measurements: antero-lateral margin, 20^{mm}; postero-lateral margin, 18^{mm}; greatest breadth, 19^{mm}. Tooth thin, strongly arched transversely and longitudinally. Trapezoidal, with antero- and postero-lateral borders about the same length. Tooth highest near the anterior angle of the postero-lateral border. From this high point the surface declines abruptly to the anterior angle of the postero-lateral border and slopes down gradually to the other borders. Surface of enamel everywhere finely punctate. Lines of growth faintly impressed or absent. Margin not crenulate.

P. carbonarius is readily distinguished from *P. crenulatus* by being much more strongly arched and lacking crenulations.

Formation and locality: Coal Measures; Newport, Indiana.

Paleontologic Collection, Walker Museum, No. 10032.

***Deltodus* and *Sandalodus* Newberry and Worthen**

That the genus *Sandalodus* has not been sufficiently well defined to separate it from *Deltodus* is shown by the disagreement among authors concerning the genus to which the species *Deltodus grandis* and *D. complanatus* should be assigned. Newberry, who described¹ both genera, says² that *D. grandis* is a typical *Deltodus*, while St. John and Worthen³ and Eastman⁴ believe that it is a *Sandalodus*. Newberry contends that *D. complanatus* is a typical *Deltodus*,⁵ while St. John and Worthen⁶ and Eastman⁷ call it a *Sandalodus*.

During the progress of the present investigation several hundred

¹ *Paleontology of Illinois*, Vol. II, pp. 95 and 102.

² *Transactions of the New York Academy of Science*, 1897, pp. 297 and 299.

³ *Paleontology of Illinois*, Vol. VII, p. 184.

⁴ *Bulletin of the Museum of Comparative Zoölogy*, Vol. XXXIX, p. 198.

⁵ *Op. cit.*, p. 102.

⁶ *Op. cit.*, p. 184.

⁷ *Op. cit.*, p. 198.

specimens of the teeth of *Sandalodus* and *Deltodus* have been studied, and one fundamental difference, perhaps of family rank, seems to distinguish one genus from the other. This difference is in the number of teeth to each ramus of the jaw, *Sandalodus* having only one tooth to each ramus and *Deltodus* having three. Only the actual finding of the teeth in place can prove this conclusion beyond all question, but the evidence in hand makes it seem more than probable. In all cochlodonts, whose full dentition is known to have more than one tooth upon each ramus of the jaw, the posterior teeth have their antero-lateral margins modified for articulation with other teeth. The teeth of *Sandalodus* have no articular edge and show no sign of other teeth having been in contact with them. No teeth of proper shape and size to fit the large plates of *Sandalodus* have been observed during the present investigation. St. John and Worthen figure and describe¹ what they call median mandibular teeth of *Sandalodus laevissimus*, but, judging from the figures, the teeth are far too much enrolled to fit the large plates of *S. laevissimus*. Furthermore, if anterior teeth were present, they should be preserved in as great abundance as the so-called posterior teeth, but, aside from those figured by St. John and Worthen, none of the kind are known, while the posterior teeth are rather common. In the Burlington limestone, where the teeth of *Deltodus spatulatus* and *Sandalodus occidentalis* are about equally common, the anterior teeth of *D. spatulatus* are numerous, though usually fragmentary; but no teeth that fit the large plates of *S. occidentalis* have been found. In regard to the dentition of *Sandalodus*, Davis says: "It does not appear probable that there was more than one tooth to each ramus of the jaw."² Davis believes that the mandibular teeth of *Sandalodus* differ considerably from the maxillary teeth, but in a study of all the specimens of this genus in Walker Museum it has proved impossible to distinguish mandibular from maxillary teeth, and this is true also of *Deltodus*.

There can be little doubt that *Deltodus* had three teeth on each ramus of the jaw. Owen has shown³ that in the complete dentition

¹ *Op. cit.*, Vol. VII, p. 166, Plate XII, Figs. 8 and 9.

² *Scientific Transactions of Royal Dublin Society*, Vol. I (1883), Series III, p. 436.

³ *Geological Magazine*, Vol. IV (1867), p. 60, Plates III and IV.

of the closely allied genus, *Cochliodus*, three teeth were present on each ramus, and it has already been shown in this paper that the same is true of *Psephodus*. Davis figures one specimen of *Deltodus* dentition with two teeth in position on one ramus.¹ In discussing this specimen he says:²

Connected with the posterior tooth a second one, hitherto regarded as a separate species under the name *Poecilodus parallelus*, has been found, which leaves no room to doubt that it is in its natural position, and from the character of its inside margin leads to the natural inference that a third tooth occupied the front or median portion of the lower jaw.

In all median teeth of *Deltodus* that are known the anterior edge is truncate or grooved, as if for articulation with other teeth.

Eastman says³ that analogy of *Deltodus* with *Cochliodus*

leads us to expect, in advance of the anterior dental plate, a series of helodus-like teeth above and below, and in front of this, at the symphysis of at least one jaw, a series of bilaterally symmetrical teeth, arched in a single plain, and corresponding to the form described by Newberry as *Helodus coxanus*.

No specimen of *Deltodus* furnishing any evidence in proof of this is known, and if, as it seems most probable, *Cochliodus* had no helodus-like teeth, there is nothing left to support such a hypothesis as to the dentition of *Deltodus*.

Sandalodus occidentalis Leidy

(Plate I, Figs. 8 and 9)

Cochliodus occidentalis Leidy, 1857 (*Transactions of the American Philosophical Society* (2), Vol. XI, p. 88, Plate V, Figs. 3-16).

Deltodus stellatus Newberry and Worthen, 1866 (*Paleontology of Illinois*. Vol. II, p. 97, Plate IX, Fig. 2 [not Fig. 3]).

Deltodus complanatus Newberry and Worthen, 1866 (*ibid.*, p. 98, Plate IX, Fig. 4).

Deltodus complanatus Newberry and Worthen, 1870 (*ibid.*, Vol. IV, Plate III, Figs. 5, 8, and 12).

Deltodus occidentalis St. John and Worthen, 1883 (*ibid.*, Vol. VII, p. 150, Plate IX, Fig. 9 [not Fig. 10]).

Deltodus intermedius St. John and Worthen, 1883 (*ibid.*, p. 153, Plate IX, Figs. 14 and 15).

Sandalodus complanatus St. John and Worthen, 1883 (*ibid.*, Vol. VII, p. 184, Plate XII, Figs. 1-4).

¹ *Op. cit.*, Series II, Plate 52, Fig. 9.

² *Ibid.*, p. 430.

³ *Bulletin of the Museum of Comparative Zoölogy at Harvard College*, Vol. XXXIX, p. 200.

Deltodus complanatus Newberry, 1897 (*Transactions of the New York Academy of Science*, Vol. XVI, p. 298, Plate XXIV, Figs. 1-7).

Deltodus occidentalis Eastman, 1903 (*Bulletin of the Museum of Comparative Zoölogy at Harvard College*, Vol. XXXIX, p. 200, Plate 4, Fig. 38, and Plate 5, Fig. 53).

Sandalodus complanatus Eastman, 1903 (*ibid.*, p. 198).

Teeth triangular in outline. In teeth of average size, 40-60^{mm} long, postero-lateral border about 1^{cm} longer than antero-lateral. The outer end terminates in an acute point; the inner end has the inner angle obtuse, the outer angle acute. Tooth slightly arched longitudinally and transversely, but, as compared with associated species, flat and thin. A low, broad ridge extends from the obtuse angle of the inner end to the outer end. From this ridge the surface declines very rapidly to the thin antero-lateral border and gently toward the postero-lateral border. Alation broad, slightly upturned. Enameled surface smooth and polished, everywhere finely punctate. Lines of growth usually not well marked. Antero-lateral border not modified for articulation with other teeth, usually straight or slightly convex.

S. occidentalis differs from *D. spatulatus* in being much less arched both longitudinally and transversely, and in having the ridge, which is not as high as in *D. spatulatus* extending from the obtuse angle to the outer end very close to the antero-lateral edge, instead of at some distance from it, as in *D. spatulatus*. The surface of the tooth declines rapidly to the antero-lateral border from the top of the ridge, and gently toward the postero-lateral border, while in *D. spatulatus* the stronger slope is toward the postero-lateral border. Antero-lateral margin not concave, as it is in *D. spatulatus*.

This species is referred to *Sandalodus* because there is evidently only one tooth to each ramus of the jaw. As has been stated, the large teeth have no articular edge, and although they are numerous in the Burlington limestone, no teeth have been found that could occupy the position of the median or anterior teeth as present in the dentition of *Deltodus*, *Cochliodus*, and *Psephodus*.

In examining a large number of fragmentary teeth of *Sandalodus complanatus* and *Deltodus occidentalis*, it was found impossible to distinguish one species from the other, and, after examining more than a hundred well-preserved teeth, the conclusion was reached that the two groups of teeth represented a single species. In large collections they grade into each other to such an extent that it is impossible to separate them, but it is not difficult to understand

how they came to be described as two distinct species from scanty material.

Eastman says¹ he is convinced that "the teeth figured as *Deltodus complanatus* in the posthumous paper of Newberry are fragments of *D. occidentalis*." These specimens are now preserved in the collection of Walker Museum, and as two of them are practically complete, there is no reason why Newberry should have identified them incorrectly, and with the union of the two species both Newberry and Eastman are correct in their conclusions.

Formation and locality: Kinderhook, Burlington, and Keokuk limestones; Iowa, Illinois, and Indiana.

***Sandalodus emarginatus* sp. nov.**

(Plate II, Figs. 1, 2 and 3)

A very large species. The dimensions of the type specimen are: 95^{mm} along the antero-lateral border, 65^{mm} along the inner end, 110^{mm} along the postero-lateral border, 26^{mm} in thickness at the thickest part. Strongly arched longitudinally and transversely. Alation strong, extending out 40^{mm} from the postero-lateral border. At the place where this alation diverges from the main part of the tooth there is a strong notch which extends to the middle of the alation in a line parallel with the main axis of the tooth. The anterior border of the alation is gently convex to near the outer angle, where it is strongly convex. The alation is thick and strong, does not turn up at the outer angle, and has a sharp ridge extending from the outer angle to the middle of its base, the sharpness of this ridge being due to the worn condition of the tooth near the inner border. Rings of growth show faintly on this worn surface. Inner end of tooth gently convex near the antero-lateral border, gently concave near the postero-lateral border. Inner posterior angle slightly obtuse. Outer end curved abruptly downward, and probably wound once and a half on itself as in *Sandalodus laevissimus*.

S. emarginatus differs from *S. laevissimus* in being more strongly arched both transversely and longitudinally, in being thicker and stronger, in having a strong notch where the alation diverges from the main part of the tooth, and in the alation being thick, convex upward, and not turning up at the point:

The types of *S. emarginatus* are two specimens, one of which is almost perfect, only a small part of the initial coil being absent; the other has lost part of the initial coil and half of the alation.

Formation and locality: Keokuk limestone; Keokuk, Iowa.
Paleontological Collection, Walker Museum, No. 10059.

¹ *Op. cit.*, 1903, p. 198.

Sandalodus alatus Newberry and Worthen

(Plate I, Figs. 3-5)

Deltodus alatus Newberry and Worthen, 1870 (*Paleontology of Illinois*, Vol. IV, Plate II, Fig. 6, p. 368).

Deltodus alatus Woodward, 1889 (*Catalogue of Fossil Fishes in British Museum*, Part I, p. 199).

Deltodus spatulatus Eastman, 1903 (*Bulletin of the Museum of Comparative Zoölogy at Harvard College*, Vol. XXXIX, p. 198).

In a paper published in 1903 (*loc. cit.*, p. 198) Eastman gives *Deltodus alatus* as a synonym of *D. spatulatus*. The specimens of *D. alatus* teeth in the collection of Walker Museum are all more or less fragmentary, but they present the following characters which serve to distinguish them from *D. spatulatus*. The pores in the enamel are much larger and fewer in number. The average number per square millimeter being four in *D. alatus* and seven in *S. spatulatus*. The postero-lateral border of *D. alatus* teeth has a broad, thin alation extending its full length. Near the outer end this alation is much broader than the accompanying ridge. In the posterior teeth of *D. spatulatus* the alation is not broad, but it is thick, and it disappears near the outer end. *D. alatus* teeth have a thin, narrow alation along the antero-lateral border, while the antero-lateral border of *D. spatulatus* teeth is thick, has no alation, and is modified for the attachment of other teeth.

This species is referred to *Sandalodus* because it seems to have but a single tooth to each ramus of the jaw.

Formation and locality: Keokuk and Burlington limestones; Iowa and Illinois.

Sandalodus porcatus *sp. nov.*

(Plate I, Fig. 14)

Type a single incomplete tooth. Length along antero-lateral edge, 34^{mm}; breadth above alation, 14^{mm}; greatest thickness, 10^{mm}. As the outer part of the alation is missing, its full dimensions cannot be ascertained. Tooth very thick and strong at the inner end, but becoming thin along the antero-lateral border near the outer end. The postero-lateral border is thick from the outer end to the alation, but becomes quite thin along the margin of the alation. The alation resembles that of *S. emarginatus* in being convex upward and very thick and strong. It occupies considerably more than half the postero-lateral border of the tooth, and diverges from this border at an angle a little greater than 100°. Tooth strongly arched longitudinally and transversely, excepting at the outer end, where the transverse arching is much less than in *S. laevissimus* and *S.*

emarginatus. The transverse arching near the inner end is much stronger than in any other species of *Sandalodus*. The outer end was probably enrolled as much as in *S. laevisimus*, but the enrolment is partially broken away. Enamel punctation so fine that it can with difficulty be detected with the naked eye. The tooth is peculiar in having a sharp ridge along the higher part running from the outer end to the inner. From the antero-lateral border six small ridges with sharp crests pass upward and forward, joining the large ridge at the top. The posterior one of these ridges is quite strong, but they decrease in size progressively toward the anterior end of the tooth, and the anterior one is very faintly marked. No lines of growth are present.

This species differs from *S. emarginatus* in the presence of the ridges above mentioned, in its greater transverse arching near the inner end and lesser transverse arching near the outer end, in the relative width of the alation, in the fineness of the enamel punctation, and in its size.

Formation and locality: St. Louis limestone; Salem, Ind.
Paleontological Collection, Walker Museum, No. 10050.

***Sandalodus latidens* sp. nov.**

(Plate I, Fig. 11)

Teeth of medium size, comparatively broad, not arched longitudinally, little arched transversely. Pointed at the anterior end. The antero-lateral margin forming a strong curve, the postero-lateral margin straight for 12^{mm} from the outer border, then diverging to form a prominent shoulder, rounded at the outer part. This shoulder extends out 8^{mm}, and from its point the postero-lateral margin passes backward in a straight line, converging slightly toward the main axis of the tooth, until it approaches the posterior border, where it curves inward and meets the antero-lateral border in the line of the main axis. Surface of enamel coarsely punctate. Lines of growth showing as delicate color markings, with no ridges present. Greatest length of tooth, 48^{mm}; greatest breadth, 27^{mm}.

The breadth, shape, and punctation of this tooth are probably of generic value, but it is here placed provisionally with *Sandalodus*, as there can be little doubt that there was only one tooth to each ramus of the jaw.

Formation and locality: Keokuk limestone; Keokuk, Iowa.
Paleontological Collection, Walker Museum, No. 10035.

***Deltodus spatulatus* Newberry and Worthen**

(Plate I, Figs. 10, 12, and 13)

Deltodus spatulatus Newberry and Worthen, 1866 (*Paleontology of Illinois*, Vol. II, p. 100, Plate IV, Fig. 7).

- Deltodus spatulatus* Newberry and Worthen, 1870 (*ibid.*, Vol. IV, Plate III, Fig. 11).
- Cochliodus costatus (pars)* Newberry and Worthen, 1870 (*ibid.*, p. 364, Plate III, Fig. 12 [not Fig. 10]).
- Deltodus spatulatus* Newberry, 1879 (*Annual Report of the Geological Survey of Indiana*, p. 346)
- Deltodopsis? convolutus* St. John and Worthen, 1883 (*Paleontology of Illinois*, Vol. VII, p. 165, Plate XI, Figs. 11 and 12).
- Cochliodus costatus (pars)* St. John and Worthen (*ibid.*, p. 167).
- Deltodus lator* St. John and Worthen (*ibid.*, p. 145, Plate IX, Figs. 11 and 12).
- Deltodus spatulatus* Newberry, 1897 (*Transactions of the New York Academy of Science*, Vol. XVI, p. 292, Plate XXIX, Figs. 8-11).
- Deltodus spatulatus* Eastman, 1903 (*Bulletin of the Museum of Comparative Zoölogy at Harvard College*, Vol. XXXIX, Plate IV, Figs. 41 and 42; Plate V, Fig. 55).

In the collection of Walker Museum are several nearly perfect specimens of *Deltodus spatulatus* teeth from the Keokuk limestone, and a large number of more or less complete specimens from the Burlington limestone. Those from the Keokuk are generally much better preserved than the ones from the Burlington. On the Keokuk specimens a few lines of growth are usually present, but the Burlington specimens rarely have lines of growth developed. One specimen from the Keokuk is remarkable for the great development of the outer end of the tooth. It curves downward and backward, lacking about 100° of forming a complete circle. From the fact that this curved part is very slender, and consequently would rarely be preserved, it is possible that it was generally developed to a much greater degree than has formerly been supposed. The complete outer end or antero-lateral margin has not been observed in any of the teeth from the Burlington limestone.

A study of these specimens substantiates Eastman's view¹ that *Deltodopsis? convolutus*², and the narrow, strongly enrolled teeth called by Newberry and Worthen *Cochliodus costatus*³ are probably the median or anterior teeth of *Deltodus spatulatus*. A great many

¹ *Bulletin of the Museum of Comparative Zoölogy at Harvard College*, Vol. XXXIX, p. 199.

² St. John and Worthen, *Paleontology of Illinois*, Vol. VII, p. 165, Plate XI, Figs 11 and 12.

³ *Ibid.*, Vol. II, p. 364, Plate III, Fig. 12? (not. Fig. 10).

teeth of this character have been found in the Burlington limestone. They are usually fragmentary, but fit the posterior teeth of *D. spatulatus*, and there are no other posterior teeth from that formation with which they can be classed.

Formation and locality: Kinderhook, Burlington, and Keokuk limestones; Illinois, Iowa, and Indiana. Numerous in the Burlington and rare in the Kinderhook.

***Deltodus attenuatus* sp. nov.**

(Plate I, Fig. 6)

Tooth triangular in outline. The type specimen measures 22^{mm} along the antero-lateral border, 27^{mm} along the postero-lateral border; inner margin, 15^{mm}. Tooth slightly arched longitudinally, little arched transversely. A ridge runs from the acute angle of the posterior border to the anterior border. The tooth slopes down abruptly from this ridge to the postero-lateral border, excepting at the posterior angle, where there is an alation that turns upward. The postero-lateral border is very thin. Toward the anterior border there is no depression, the rest of the tooth being the same height as the ridge. The antero-lateral margin is very thick at the inner end, but thins out toward the outer end. The posterior inner angle is obtuse, the posterior outer angle acute. The surface of the enamel is very finely punctate throughout.

This species differs from *Deltodus angularis* (*Orthopleurodus carbonarius*) St. J. and W. in being much narrower and thinner, much less arched both longitudinally and transversely, and in the character of the ridge.

The type specimen, a posterior tooth from left mandible or right maxilla, is from the Coal Measures near Kansas City, Mo. It is now in the collection of the University of Kansas.

PLATE I

FIG. 1.—*Psephodus acutus* sp. nov. Median tooth of left mandible or right maxillary.

FIG. 2.—*Psephodus legrandensis* sp. nov. Dentition of one jaw; anterior teeth restored in outline.

FIGS. 3-5.—*Sandalodus alatus* N. and W. Fig. 4 shows the alations on both sides of the tooth. Fig. 3 has the alations restored in outline. Fig. 5 shows the characteristic punctuation of the teeth.

FIG. 6.—*Deltodus attenuatus* sp. nov. Posterior tooth; anterior end and part of alation restored.

FIG. 7.—*Psephodus carbonarius* sp. nov. An almost perfect posterior tooth.

FIGS. 8 AND 9.—*Sandalodus occidentalis* Leidy. Fig. 8 shows the characteristic shape of the anterior edge of the teeth of this species. Fig. 9 shows posterior end of tooth; anterior end restored from more perfect specimens.

FIG. 11.—*Sandalodus latidens* sp. nov. A perfect tooth.

FIGS. 10, 12, AND 13.—*Deltodus spatulatus* N. and W. Figs. 10 and 13 show the characteristic shape of antero-lateral edge of the teeth of this species; anterior end restored. Fig. 12 shows the shape of the posterior end of the teeth of this species; anterior end restored.

FIG. 14.—*Sandalodus porcatus* sp. nov. Tooth with part of anterior end and alation restored.

PLATE II

FIGS. 1-3.—*Sandalodus emarginatus* sp. nov. Fig. 1, top view of complete tooth. Fig. 2, antero-lateral edge of same tooth; outline to show relation of postero-lateral edge. Fig. 3, postero-lateral edge of same tooth.



